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UNION PACIFIC RAILROAD.

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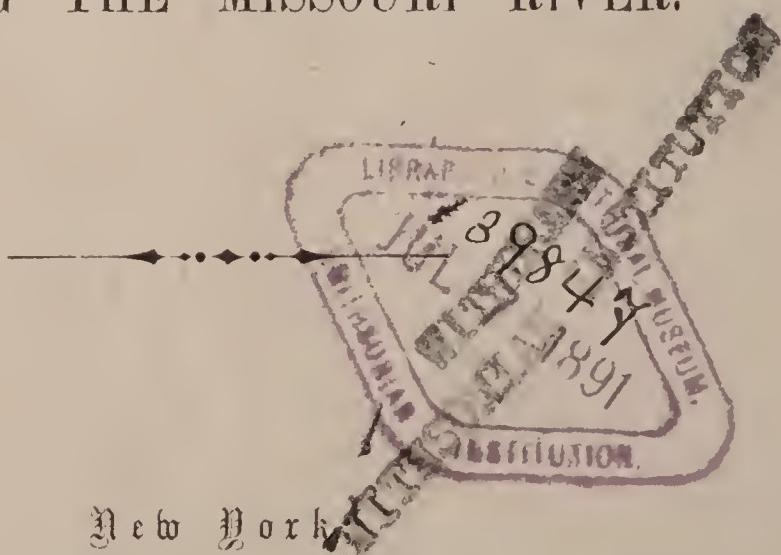
REPORT

OF THE

CHIEF ENGINEER

ON

BRIDGING THE MISSOURI RIVER.



New York

D. VAN NOSTRAND, No. 192 BROADWAY.

1866.





UNION PACIFIC RAIL ROAD.  
MAP

TO ACCOMPANY REPORT

OF  
GEN. G. M. DODGE, CHIEF ENGINEER

ON THE CROSSING OF THE

MISSOURI RIVER

Dated January 15, 1867.

TABLE OF DISTANCES:

Description of Line	Reference to Map	Miles
Child's Mill line	A.E.K.	5.83
Childs Mill & Papillion Valley	A.F.O.	8.77
High crossing south of railroad in Omaha	A.C.M.K.	9.27
High crossing, Stone Quarry (not practicable)	A.D.L.K.	9.41
Low Bridge at telegraph crossing # Ainsworth line	A.B.G.H.I.K.	12.33
Low Bridge N.W.R.R. grounds, telegraph crossing present track, with 66 feet maximum grade	N.B.C.M.L.K.	12.30
Low Bridge N.W.R.R. grounds, Ainsworth line, with 30 feet grade,	N.B.G.H.I.K.	11.82





UNION PACIFIC RAILROAD.



REPORT

OF THE

CHIEF ENGINEER

*Dodge, G.A.*

ON

BRIDGING THE MISSOURI RIVER.



New York:

D. VAN NOSTRAND, No. 192 BROADWAY.

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1867.

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# UNION PACIFIC RAILROAD.

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## REPORT

*Of Genl. G. M. Dodge, Chief Engineer, in relation to Bridging  
the Missouri River.*

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NEW YORK, December 3, 186<sup>6</sup>

T. C. DURANT, Esq.,  
*Vice-President and General Manager,*  
*Union Pacific Railroad :—*

SIR : I have the honor to submit for the information of the Company, such data as the surveys of the Missouri river, so far as made, have furnished, having in view the proper point to bridge the river ; and the approaches to the bridge from the east and the west.

The river has been systematically sounded, to determine generally the depth of water, sand, and the material that piers would rest on.

Rock has been discovered at several points, but as yet not entirely across the river ; the pipe sunk on east side having gone through the sand, and reached a hard substance that we could not force through with the usual means.

Taking into consideration the approaches, east and west, on the river, I hold that we are confined, in bridging the stream, to a distance of some eight miles, included between the Buschey Ferry, and Child's Mill. The high-water table on the east side, approaches very near the bank of the river for nearly four miles of the distance, while it is not over one and one half miles off, on any portion of this front. In this distance, four crossings have been pretty thoroughly examined, viz. :

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I. The point at Telegraph Poles.

II. The crossing near where the M. & M. R. R. line strikes the river.

III. The crossing about two miles below, at the ravine above the Stone Quarry.

IV. The crossing at Child's Mill.

The first, at Telegraph Poles, I consider the best for a low bridge with draw ; and the crossing at Child's Mill the best for a high bridge.

The approaches to all the crossings are equally feasible on the east side ; on the west side, the first would end on our depot grounds at Omaha.

The second is on the table just south of the city, and would go into Papillon Valley on our present line.

The third could be brought up the river to the depot, or go out over the south part of the city ; or, what would be probably better, follow up the ravine opposite the crossing, and cross the divide at a new point south of present crossing, entering Mud Creek Valley about one mile below the present summit. This line has not been fully surveyed, but it is thought we may get through on a thirty feet grade.

The fourth, or Child's Mill crossing, follows up a ravine opposite the crossing, cutting through the divide, and in one mile from the river strikes the Mud Creek line, some five miles from Omaha, shortening the line about seven and a half miles over Crossing Number 1, and avoiding the three miles of sixty-six feet grade at Omaha ; as Mud Creek is reached on this line with a thirty-feet grade. The summit cut is one hundred and five feet deep at its highest point, and with a base of twenty feet, and slope of one-quarter to one, has about one hundred and seventy-five thousand cubic yards of earth to waste.

A bridge at Child's Mill has the advantage, on the west side,

of abutting against the high bluff; and, second, a narrow river, and bridge, well protected from the wind by bluffs, on west side, and timber on east. A high bridge, at this point, would have one and one-half miles of trestling or embankment on the east side to reach grade. It would be eighty feet high above foundations, and would give fifty feet in clear from extreme high water to bottom of lower chord; and would not cost any more than a low bridge at Telegraph Poles.

The grading on east side would cost about one hundred thousand dollars, which would be in addition to cost of bridge.

A low bridge at or near Telegraph Poles, is estimated at two thousand one hundred feet long, having one half mile of trestling on each side. The river, at this point, has not materially changed in several years, while above and below it has changed from three hundred feet to three-quarters of a mile.

The extra cost of turn-table draw and centre pier, brings the bridge, in cost, up to that of high bridge at Child's Mill; and even if the bridge is located here, I feel disposed to urge upon the Company the building of a high bridge. My reasons are briefly:

*First.*—It does away with all expenditure in confining the channel, which I consider an experiment. No theory that I know of will meet such a question. It is a matter to be decided by our observation of the river—our experience on it—and, finally, by actual experiment. We might invent a plan that would confine the channel at first trial and with little cost; or we might sink a large amount of money and even then not succeed.

*Second.*—It relieves the Company from the hostility of the boating interest; gives no excuse for the long list of law-suits that all draw-bridges have had to meet; obviates unfriendly legislation, and gives a boatable channel under

the bridge at all seasons of the year, no matter what freaks the yearly freshets may play with the river.

*Third.*—It is almost impossible to place obstacles in current of channel that will turn it. The cause of change of channel, which seldom remains at one point during one month of the year, is the fact that it cuts the bank on one side or the other, or both, until its course is naturally changed, from the distance and direction it eats into the bank—not from the obstructions it meets ; and the moment the channel begins to change, it deposits its sediment in the old channel, cuts it entirely off, and gradually fills it up.

*Fourth.*—A high bridge being built, all expense has been incurred, the trouble of the draw avoided, and all accidents obviated, and it will give better satisfaction to all interests. And I believe that if the Company build anything but a high bridge, they will always regret it, and it will always be a source of annoyance, legislation, and cost.

*Fifth.*—The cost of a high bridge over a low one, when you take into consideration the uncertainty of the cost of confining the channels to the draw, is not enough, in my opinion, to overcome any one of the objections to a low bridge.

These, and many other reasons, that it is not necessary for me to mention here, induce me to be decidedly in favor of building a high bridge, no matter what point of crossing the river you may select. At Telegraph Poles it will cost most, but not over one hundred and fifty thousand dollars more than any other point mentioned. You can rise to it on a fifty-feet grade, running up each side on a trestle one mile long.

A high bridge is only thirty-five feet higher than a low bridge, as ice and drifts make it necessary that low bridges should have at least fifteen feet in the clear between extreme high water and bottom of lower chord.

The foundation at Telegraph Poles, at one point is rock

over two-thirds of the distance across, and at another point about one-third ; at all other points, pile foundations would have to be used. At Child's Mill, if foundations are put in during low water, only two piers, and perhaps but one pier would come in the water.

I submit herewith an Approximate Estimate of cost of bridges, made from the best data at hand, being governed in prices by what our limited data indicate to us as a fair cash value. The stone for masonry, if obtained from the Platte River Quarries, would have to be hauled seven to nine miles to reach the railroad, and ten to fourteen miles on railroad. Quarries are being developed on North Western Railroad, right on the line of the road, which may be made available. The quarries on the Platte we know to be good and available. Near Pacific City, on Council Bluffs and St. Joseph Railroad, some fine quarries are being opened. I have not seen them, but am told that they are superior to any other in feasibility of working, quality of stone, and thickness of course ; if this be so, they are the nearest, and can be made available with less expense than any other, as the Council Bluffs and St. Joseph Railroad runs right alongside of them, and would be within a short distance of any of the bridging points.

The cost of foundations is a matter of conjecture, as no such work has as yet been done in the Missouri river. I have estimated at usual cost of such work ; and I desire it distinctly understood, in submitting this estimate that I have not made a close calculation, aiming merely to give the Company something of an idea of the quantities, and about the cost of the different kinds of work.

*High Bridge, at Child's Mill.*

4,250 C. Y. Masonry to Piers, at \$20.00.....	\$85,000 00
1,250 " " " Abutments, at \$20.00.....	25,000 00
12,780 lin. ft. Piles in foundation, \$1.50.....	19,305 00
121,000 lin. ft. B. M. Timber in foundation, at 50 cts..	6,050 00
2,000 lin. ft. of Truss, at \$65.00.....	130,000 00
1,570,814 ft. B. M. Timber in Trestle, at \$50.00.....	78,540 00
Engineering, 10 per cent.....	34,389 00
	<hr/>
	\$378,284 00
Cost of 1 mile road west side.....	150,000 00
	<hr/>
	\$528,284 00

*Low Bridge at Telegraph Poles.*

1,650 C. Y. Masonry in Piers, at \$20.00.....	\$33,000 00
420 " " " Abutments at \$20.00.....	8,400 00
874 " " " Centre Piers, at \$20.00.....	17,480 00
12,000 lin. ft. Piles in foundation, at \$1.50.....	18,000 00
108,000 ft. B. M. Timber in Crib, at 50 cents.....	5,400 00
1,362,500 " " " Trestle, at 50 cents.....	68,120 00
6,666 C. Y. Stone in Crib, at 5 cents.....	33,300 00
708,950 ft. B. M. Timber in Trestle, at 50 cents.. .	21,268 00
1,800 lin. ft. Truss, at \$65.00.....	127,000 00
300 " " " .....	31,500 00
Turn-Table.....	6,500 00
Engineering, 10 per cent.....	33,997 00
	<hr/>
	\$406,975 00

In a purely engineering point of view, without regard to the advantage of crossing directly at Omaha, or the use of our own depot grounds, I am decidedly of the opinion that the best point for bridging the river with a high bridge, is at Child's Mill. It is shortest, gives best grades, and leaves out entirely the sixty-six feet grade at Omaha.

A bridge here can be put up in low water, in shortest time, with least cost, and gives us a high bluff to abut against on west side, with plenty of distance to rise to grade on east side, and shortens through distance seven and one-tenth miles.

*Second.*—If desirable to avail ourselves of the crossing at Omaha, for the use of our shops and grounds, the best point of crossing for a high bridge is at or near the present crossing of the M. & M. R. R. line. A high bridge here will cost more than at Child's Mill, on account of the necessity of increased length on west side to reach table south of city, while it has the advantage at east side of reaching high water table, six hundred feet from bank of river.

*Third.*—If low bridge is decided upon, the point at or near Telegraph Poles is best, and this point has the advantage of being one-half, and perhaps three-quarters, on rock bottom. It is also the best point, in my opinion, for confining the channel, from the fact that the river has not materially changed at this point for at least eleven years, and it is easier to hold a channel in its natural course, than to force it out, as would have to be done at some other points, to conform to the draw.

The distance on east side of river at this point, to high-water table, is about two thousand feet ; on west side, high-water table will not be reached until grade strikes the depot grounds.

The distance over different lines is as follows—between a common point at Council Bluffs—say, east line of Section 3—and the common intersection in Mud Creek Valley :

Child's Mill Line.....	6.14 m.
M. & M. R. R. crossing.....	9.84 m.
Telegraph Poles crossing.....	13.69 m.
From N. W. R. R. Depot and Telegraph crossing.....	12.53 m.
N. W. R. R. Depot and Child's Mill.....	7.14 m.

All crossings except Child's Mill, will use the present track west of Omaha, and have three miles of sixty-six feet grade to overcome.

Child's Mill crossing has maximum grades of thirty feet only ; it is three and seven-tenths miles shorter than the M. and M. crossing ; seven and fifty-five hundredths miles shorter than Telegraph Poles crossing, and six and four-tenths miles shorter than direct crossing by Telegraph Poles from North Western depot grounds ; and taking these grounds as a common point, it is five and four-tenths miles shorter.

The masonry in piers and abutments can be materially reduced on high bridge, by running over upper chord on that portion of bridge over the low bottoms each side of the river, and through the bridge over the channel of river. The estimates have been made for running through bridge for entire length.

The surveys on the river are being pushed forward, and when completed may indicate some point more favorable for a crossing than any of those mentioned ; but I am convinced that generally, the features above indicated will not be changed. A detailed examination of the river may lead us to locate the bridge a few hundred feet north or south of any one of the above points, which will not change the general location, or the approaches to the bridge.

I am, very respectfully,  
Your obedient servant,

G. M. DODGE,  
*Chief Engineer.*

## SUPPLEMENTAL REPORT.

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ENGINEER'S OFFICE, U. P. R. R.,  
OMAHA, N. T., January 15, 1867. }

T. C. DURANT, Esq.,  
*Vice-President and General Manager,*  
*Union Pacific Railroad,*  
*No. 20 Nassau st., New York :*

DEAR SIR : I have the honor to submit herewith the additional maps, profiles, and estimates, of bridge across the Missouri river.

My former report was based, to a considerable degree, upon data from only partial surveys. The surveys then being made have been completed, and the data submitted herewith is the result of personal examination and actual survey.

The sounding parties are all at work giving the river bed a thorough examination at three notable points for bridging, viz. : Child's Mill, Table south of Omaha, and Telegraph Poles.

The Child's Mill line I discussed in former report ; the additional surveys made, go to substantiate all said in relation to that line, and add to its feasibility. Estimates are attached, marked "A." The line on table just south of our present railroad line through Omaha has been given a thorough examination, and I submit estimates attached, marked "B."

I feel sure that it is practicable to go out on the line, marked "A, C, M" on map, near the present railroad line, with thirty feet grade ; that it is also practicable to swing

north from bridge and go to our depot grounds on a new line, or on the line now built. We can also, without much difficulty, curve to south from west end of bridge, and take the line run by Mr. Ainsworth, going into Mud Creek at point "I" on map. So that all the points unsettled on this line, when my former report was made, are settled in its favor. It will be seen that the great width of the river and bottom land at this point, makes it cost two hundred thousand dollars more than at Child's Mill, after increasing length of Child's Mill bridge one thousand feet.

I submit profile of line for low bridge, at Telegraph Poles, marked "A, B," with estimates attached herewith; also profile of Ainsworth line, which should be considered with it, giving a thirty foot grade to Mud Creek at Station 366 on map, marked "G, H, I."

This crossing I consider best for low bridge. Rock has been found for a distance of 1,500 to 2,000 feet above Telegraph Poles and across Sand bar, when it drops off. The question of foundation, I think, is settled favorably for all crossings, as we can sink our piles about thirty-five feet at most all the points and fill them with rubble, and make our foundation perfectly safe.

Piers in bottom land rest on concrete; at Telegraph Poles we can rest a portion of our foundation on rock bottom and a portion on piles.

My late examination of river renders me more decided in favor of high bridge. The fact that we can overcome all objections to high grades, avoid all lawsuits and injunctions, all expense of confining channel, and not in any way be dependent on future uncertainties and experiments in confining our channel, avoid all difficulty of swift current through draw, and the great obstruction of centre pier in such a river, appears to settle the question in favor of high bridge. As a general rule, past experience has taught us not to build a low bridge over a navigable river, when a high one can be built without materially increasing cost.

Estimates for bridge have been made from soundings on best location for each line; masonry estimated over bed of river for running through bridge, and over bottom land to run on top chord of bridge.

Foundation for piers in river is piles and rock bottom, on bottom land is concrete. Trestle work is estimated with double posts, with the intention that before it will have to be replaced it will be made permanent bank. Prices have been set upon the work that our past experience tells us it can be done for.

Stone can be found near Bartlett Station, on Council Bluff and St. Joseph road, sufficient to build the bridge. It can be loaded in cars for \$1 50 per cubic yard, and be delivered at river at \$2 at highest per cubic yard, making \$3 50 per cubic yard delivered.

We have estimated for superstructure of "Howe's Truss" for high bridge and all spans of low bridge, except centre span. The centre span of the low bridge is iron truss three hundred feet long. Act of Congress requires three hundred and fifty feet for bridges over Mississippi and Missouri rivers in all charters granted last winter.

An iron truss for high bridge is preferable, but will cost nearly twice as much as "Howe's truss;" still I think, in the end it will be better policy, and more economical to use it. So important a structure should take advantage of all improvements that genius and experience have added to any old plans or material.

Iron bridges for such spans and work, are being used in all structures of as much importance as this. It is considered to be much more economical in the end, and by far the safest; if wood truss is used, I recommend Howe's.

I believe the maps, profiles, and estimates, and my former report with that now submitted, will give the Company sufficient data for them to fully understand the questions, and decide the location.

I consider the subject in a purely professional point of view, and in an engineering point of view there seems to be

no question as to the best location of the bridge, and that is near or at "Child's Mill." I can reduce length of bridge here easily, if desired, by crossing at narrowest point of river, and going up another ravine connecting with railroad in Pappillon Valley, instead of Mud Creek, as shown on map and profile by line marked "A, F, O."

The Child's Mill location has the great advantage over all other points of saving distance. The high bluffs on the west side to abut against, the course of channel fixed by formation of valley at this point, narrow river, the protection that bridge has from bluffs and timber, and the fact that the river nearly washes bluffs on the west side, with a direction to the current that will always hold it to that side; also, the distance saved on all through freight, travel and traffic, decreases running expenses, with the avoiding of high grades, striking Mud Creek so low that very little expense is incurred in reducing the Mud Creek grade down to thirty feet; and the fact also determined by our surveys that we can reach our depot grounds at Omaha, from west end of bridge, by falling gradually to valley of Missouri river, and running up the valley to Omaha.

These advantages, and others that have been brought before the Board, decide beyond question that this is the location for a bridge in a purely engineering point of view.

The question of a commercial point at Omaha; of the use of our depot grounds at that place, and the better satisfaction it will give the people of that city; and how much these should weigh against the nationality of the work, the engineering advantages, the distance saved, the distance hereafter saved in running, the percentage gained on all traffic going from the Atlantic to the Pacific; and the fact of the location not only being made for the present, but for ten, twenty, and one hundred years hence, are matters for the Company to consider.

If the local interests of Omaha and our own expenditures at that place—our grounds and shops—are sufficient to overcome extra expense and cost, the engineering advantages and

the facts mentioned, then the location just south of present road in Omaha is the best ; and this is the second best point for high bridge on the river examined.

The objection heretofore urged to this point of not being able to go west near our present road on a thirty-foot grade is avoided by our last survey ; and our depot grounds made available and the commercial interests of Omaha satisfied. If allowed to run to the summit on a forty-foot grade, I can cheapen the line from west end of bridge materially ; and I cannot see the objection to it, as our built line down Mud Creek and up Pappillon has several forty-foot grades. We can also, on this location, use the old road until such times as increased business demands change of grade on east side of summit.

The thirty-foot grade from bridge at this point runs us down to level of valley most too far east for good connection with eastern roads. I would therefore recommend, if bridge is decided upon at this point, that we approach on east side with forty-foot grade. It would reduce cost of trestle and bank.

As to low bridge, the question as to confining channel, the increased swiftness of the current and proper means to avoid it, the danger from lawsuits and other objections discussed in my former report, I think we should, if possible, avoid. You fully understand and can determine these better than I.

The confining of channel within limits of natural bank of river, turning of channel at all seasons of the year, through draw, without an increase of current that will render it objectionable, I consider an experiment that no one can predict the *cost, time, trouble, or expense* of. But if the bridge is decided upon, I recommend the point at Telegraph Pole. To reach our depot grounds at west end of bridge, that portion on bottom would have to be on a curve, and probably trestle on east approach.

The river is now threatening this location from Buchey's Ferry, to point of turning south.

The systematic soundings and surveys being made at Tele-

graph Pole, at crossing south of Omaha, and at Child's Mill, will render us fully able to finally locate position of piers of bridge on either line you may select.

*Table of Distances.*

Child's Mill line, marked on map "A, E, K," .....	5.83 miles.
Child's Mill and Pappillon Valley, marked on map "A, F, O," .....	8.77 "
High crossing south of railroad in Omaha, marked on map "A, C, M, K," .....	9.27 "
High crossing, Stone Quarry (not practicable), marked on map "A, D, L, K," .....	9.41 "
Low Bridge at telegraph crossing, and Ainsworth line, marked on map "A, B, G, H, I, K," .....	12.33 "
Low Bridge, N. W. R. R. grounds, telegraph cross- ing, present track with sixty-six feet maximum grade, marked "N, B, G, M, L, K," .....	12.30 "
Low Bridge, N. W. R. R. grounds, Ainsworth line, with thirty feet grade, marked "N, B, G, H, I, K," .....	11.82 "

*Distances compare as follows:*

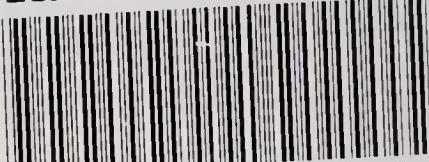
Child's Mill line, "A, E, K," shorter than line on table south of Omaha, "A, C, M, K," .....	3.44 miles.
Child's Mill line, "A, E, K," shorter than line by Telegraph Pole, marked on map "A, B, G, H, I, K," .....	6.50 "
Child's Mill line shorter than line from N. W. R. R. by Telegraph Pole, sixty-six feet grade, marked "N, B, G, M, L, K," .....	6.47 "
Child's Mill line shorter than line from N. W. R. R. depot grounds, via Telegraph Pole depot grounds, with thirty feet grade, marked "N, B, G, H, I, K," .....	5.99 "

ABSTRACT OF ESTIMATES OF DIFFERENT CROSSINGS OF MISSOURI RIVER.

	Cost of Bridge Proper.	Cost of Approaches, East and West.	Superstructure, Entire Length of Line.	Engineering and Incidentals.	Total Cost.	Length of Truss Bridge.
1. High Crossing, Child's Mill .....	\$415,726 34	\$347,935 56	\$69,960 00	\$41,681 09	\$875,302 99	3,000 feet.
2. Ditto South of Omaha.....	693,379 28	265,001 82	63,720 00	51,105 05	1,073,206 15	5,200 "
3. Low Crossing at Telegraph Poles, and Ainsworth Line, with 30 foot grade.....	533,922 04	228,654 20	130,680 00	44,662 81	937,919 09	2,900 "

NOTE.—The Superstructure on line 2 is estimated only to intersection with present track at Station 166.

Mr. Ainsworth's Estimate is taken on line "C," on the part run by him.



0 020 126 029 2

It will be observed that these estimates are made for bridge proper ; and for a road to be built from a common point on east side of river, to the intersecting point on our line in Mud Creek Valley. That I have increased price of trestling over old estimate from \$50 to \$90 per thousand feet, and truss from \$65 to \$80 per lineal foot, as in former estimate. I understood truss was delivered at Omaha for \$65 per lineal foot, while I find it was delivered at Chicago at that price. \$15 per lineal foot is added for transportation from Chicago to Omaha.

Masonry is put in at \$20 per cubic yard. This change in prices makes the difference in cost of bridge proper as compared with former estimate.

In that estimate I did not estimate approaches as I have in this. In the estimate now submitted, I have increased length at Child's Mill bridge from two thousand feet to three thousand feet, throwing one thousand feet more on east side of river to avoid all contingencies from high water, &c.

Bridge at Child's Mill, line "A, F, O," can be reduced to two thousand feet on line "A, E, K." I believe it would be safe at two thousand five hundred.

I do not estimate for any unusual obstructions in building of bridge. I estimate what bridge would cost, built in usual manner, with usual contingencies. And although the Missouri river has never been bridged, or its currents and sand contended with in putting in foundations, yet I do not anticipate any unusual difficulties.

Neither have I, in low bridge, given any estimate for confining channel, or turning it at all seasons of the year into draw, without increase of current. This is also a matter of experiment, and merely guess-work as to cost.

The line marked A, D, L, K, on map, known as "Stone Quarry line" (you have map and profile in New York), I don't consider or estimate, as it is impracticable in comparison with other lines.

I am, very respectfully, your obedient servant,  
G. M. DODGE,  
*Chief Engineer.*